

M. Sc. Wine, Brewing and Alcohol Technology Course

(Affiliated to University of Pune)

Eligibility:

B. Sc. in Wine Technology/ Post Graduate Diploma in Industrial Fermentation and Alcohol Technology/ B.Sc. in Bio-Technology/ Microbiology/ Chemistry/ Agriculture/ Botany/ Zoology/ and B.E. /B. Tech. (Chemical Engineering/ Biotechnology)

M. Sc. (WBAT) Revised Syllabus

University of Pune
Proposed Revised Syllabus for
M. Sc. Wine, Brewing and Alcohol Technology Course
(Based on Choice Based Credit System)

Course Structure

1. There will be FIVE courses in each semester.
2. Each course will be of 100 marks and 75 lectures.
3. Practical course will be of 24 practical having each practical is of 4 hours.

M. Sc. Part – I **Semester-I**

WT 1.1 Viticulture
WT 1.2 Microbiology of Alcohol, Beer and Wine
WT 1.3 Biochemistry of Alcohol, Beer and Wine
WT 1.4 Practical-I
WT 1.5 Practical- II

Semester-II

WT 2.1 Alcohol Technology-I
WT 2.2 Brewing Technology-I
WT 2.3 Enology-I
WT 2.4 Chemical and Plant Engineering-I
WT 2.5 Practical- I

Semester-III

WT 3.1 Alcohol Technology –II
WT 3.2 Brewing Technology-II
WT 3.3 Enology-II
WT 3.4 Chemical and Plant Engineering-II
WT 3.5 Practical- I

Semester-IV

WT 4.1 Business Management
WT 4.2 Industrial waste treatment & Environmental management
WT 4.3 Alcohol Technology –III
WT 4.41 Second Generation Biofuels
WT 4.42 Advance Brewing Technology
WT 4.43 Advance Enology
WT 4.5 Project work (Which will be of individuals/groups/Inplant training)

**M. Sc. - I
Semester-I
WT 1.1 Viticulture
Summary**

| Credit No. | Credit title | Number of teaching clock hours per credit |
|-------------------|---------------------------------------------------------------|--------------------------------------------------|
| 1.01 TC | The grapevine and its varieties | 15 |
| 1.02 TC | Vine pests & diseases | 15 |
| 1.03 TC | The vine and role of climatic factors on harvesting of grapes | 15 |
| 1.04 TN | World scenario of grapes | 15 |
| 1.05 TN | Biotechnological tools to access genetic purity and diversity | 15 |
| 1.06 TN | Soil for cultivation of grape vine | 15 |
| | | 75+15=90 |

Note:

- 1) **3 TC Credits and any 2 Credits from TN.**
- 2) **The subject covers total 5 Credits i. e.**
Teaching clock hours = 60 clock hours and
- 3) **Total clock hours per course= 75+15=90 clock hours**

WT 1.1 Viticulture

1.01 TC : The grapevine and its varieties,

Terroir: The qualities of the soil; Destroyed at the root? Mechanization in the vineyard. Varieties of grapes; the most important white wine grape Varieties; The most important Red wine grape Varieties, Vine cultivation: Pruning the vines; Methods of cultivation; Integrated Pest management.

1.02 TC: Vine pests & diseases

Serious Vine diseases; Some feared Vineyard pests; Phylloxera; Bacterial diseases of the Grapevine- Pierce's disease, Crown Gall; Viral diseases of the Grapevine- Fan leaf degeneration; Grapevine Leaf roll; Fungal diseases of the Grapevine- Downy Mildew, Powdery Mildew, Black rot, Dead-arm, Anthracnose, Pierce's diseases, Crown Gall. Sanitary and phytosanitary measures of wine grapes

1.03 TC: The vine and Role of climatic factors on harvesting of grapes.

The origin, taxonomy and Biogeography of the grapevine- Prehistoric evidence for vitis, differences between muscadine grapes & Evatis species; The grape and maturation processes- Berry structure, Development stages of the grape, Flavor and aroma compounds in the mature grape, grape derived phenolic compounds. The working years in the vineyard- Care of the soil & more; Grape ripeness;

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Harvesting the grapes. Taking delivery of the harvest. Preparing the grapes, Specific gravity & potential alcohol: Pressing. Noble & mass produced wines.

Harvesting and post-harvest management: maturity index, changes in the wine grapes during maturation, ripening, grading; fumigation; packing, export of grapes, processing of grapes, transportation and marketing. Disorders: ecological disorders, physiological disorders, eco-physiological disorders, non-specific disorders

1.04 TN: World scenario of grapes

Grape producing countries, topmost grape and wine producing countries in world, Grape production scenario of India and major states in India. Statistical data of grape production global and Indian scenario.

1.05 TN: Biotechnological tools to access genetic purity and diversity.

Applications of genetical control mechanism in grapes development. Development of grape varieties resistant to various biotic and abiotic stresses.

1.06 TN: Soil for cultivation of grape vine

Soils and Climate: Soil formation, soil classification. Types of soils required for grapevine cultivation. Major and minor soil elements. Climatic conditions: temperature, rainfall, humidity, wind and light for grapevine cultivation.

Reference Books:

1. American Society for Enology and Viticulture- Seattle.
2. Diseases and pests- Phil Nicholas, Peter Magarey, Malcom Wachtel.
3. Viticulture Vol.I- Resources- P. R. Dry, B. G. Coombe.
4. Viticulture Vol. II- Practical- P. R. Dry, B. G. Coombe.3
5. Pesticide Applications in Vineyards- John Kent, Richard Early.
6. Soils for fine wines- Robert E. White.
7. Australian Society of Viticulture and Enology - Andrew markides, Richard Gibson.
8. Grape pest management- Donald L. Flaherty, L. Peter Christensen, W. Thomas Lalini, James J. Marosis, Phil A. Philips, Lloyd T. Wilson.
9. Introduction to wine making – Viticulture and Enology 3- Prof. Ralph E. Kunkee.
10. Biology of microorganisms on grapes, in must and in wine- Konig Helmut.

**WT 1.2 Microbiology of Alcohol, Beer and Wine
Summary**

| Credit No. | Credit title | Total hours per credit |
|------------|------------------------------------------------------------------------|------------------------|
| 2.01 TC | Classification of microorganisms, staining techniques and cell biology | 15 |
| 2.02 TC | Basic techniques in Microbiology | 15 |
| 2.03 TC | Microbiology of yeast | 15 |
| 2.04 TN | Solid state fermentation | 15 |
| 2.05 TN | Contamination control in alcoholic fermentations | 15 |
| 2.06 TN | Industrially important fermentation products | 15 |
| | | 75+15=90 |

Note:

- 1) 3 TC Credits and any 2 Credits from TN.
- 2) The subject covers total 5 Credits i. e.
Teaching clock hours = 60 clock hours and
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2.01 TC: Classification of microorganisms, staining techniques and Cell biology:

Occurrence, types of microorganisms. Classification of microorganisms: Difference between prokaryotic and eukaryotic cells, types of bacteria, fungi, viruses, protozoa and algae. Detail classification of fungi. Stain and staining procedures - Definition of stain and dyes, types of stain; procedure and mechanism of Gram staining, Acid fast staining. Negative staining. Detailed study of bacterial cell organelles, cell wall, cell membrane, capsule, endospore, flagella, types of flagella, mechanism of flagellar movement. Growth: Definition of growth, factor affecting the growth curve, measurement of growth, continuous culture, chemostat, turbidostat, dialysis technique, synchronous growth.

2.02 TC: Basic techniques in microbiology

Sterilization & Disinfections: Definition of sterilization & disinfections; physical agents - application of high temperature & low temperature for killing microorganisms (Moist heat & dry heat). Low temperature, Refrigeration or Subzero temperature, Desiccation, Osmotic pressure, Radiation, U V light, X-ray, gamma rays & cathode rays, filtration (Bacteriological filter, Air filters), HEPA filters, ultrasonic & washing. Chemical agents - characteristics of ideal disinfectant, selection of chemical antimicrobial agents - phenol & phenolic compounds, alcohol, halogens, heavy metals & their compounds, detergents, aldehydes, gaseous & chemo sterilizers. Nutrition: Autotrophic, heterotrophic & photosynthetic organisms, uptake of nutrients. Pure culture techniques-enrichment culture technique, design & preparation of media - Nutritional requirements ingredients of media, types of media. Preservation of pure culture and their techniques, slant culture preservation, Lyophilization.

2.03 TC: Microbiology of yeast

Definition, comparison with other microorganisms, yeast morphology and taxonomy, yeast cell structure and functions of various cellular components. Nutritional requirements of yeast, Aerobic and anaerobic metabolic pathways in

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yeast for sugar dissimilation, Isolation and Maintenance of yeast, Stoichiometry of alcohol production.

2.04 TN: Solid state fermentation

Comparison of solid state fermentation with other types of fermentations, Importance of solid state fermentation, the industrial production of various SSF based products.

2.05 TN: Contamination control in alcoholic fermentations

Introduction to antibiotics, Mechanism of various antibiotics, Effect of microbial contaminants on alcoholic fermentations. Role of antimicrobial substances controlling contamination in alcoholic fermentation,

2.06 TN: Industrially important fermentation products

Role of fungi in various fermentations, Examples of various fermentations using yeast with special reference to Glycerol, baker's yeast, etc.

Reference Books:

1. The microbial world – Stainer
2. General Microbiology – Volume I and II Power and Dagainwala
3. Elements of Microbiology – Pelczar
4. Principles of Microbiology – Sanyogita Wadikar
5. Microbial Technology – Papler Vol. I and II
6. Industrial Microbiology – Casida
7. Wine Microbiology and Biotechnology- Graham H. Fleet.
8. Production wine analysis- Zoecklein B. W.
9. The yeast- Lodder H. J.
10. The chemistry and biology of winemaking- Hornsey Ian.
11. Wine and beverage- Bell D. A.

**WT 1.3 Biochemistry of Alcohol, Beer and Wine
Summary**

| Credit No. | Credit title | Total hours per credit |
|-------------------|-------------------------------------------------|-------------------------------|
| 3.01 TC | Biochemistry of living cells | 15 |
| 3.02 TC | Proteins, carbohydrates and lipids | 15 |
| 3.03 TC | Biochemistry of alcoholic fermentation | 15 |
| 3.04 TN | Protein Synthesis | 15 |
| 3.05 TN | DNA and chromosomes | 15 |
| 3.06 TN | Production of biogenic amines & ethyl carbamate | 15 |
| | | 75+15=90 |

Note:

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- 2) The subject covers total 5 Credits i. e.
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3.01 TC: Biochemistry of living cells

Classification of living cells, structure and function of cells DNA/RNA and protein synthesis. Photosynthesis: Definition, importance and mechanism, light reaction, Dark reactions and factors affecting the photosynthesis rate.

3.02 TC: Proteins,carbohydrates and lipids

Characteristics and classification of proteins, protein structure and proteins in sugarcane juice. Amino Acids: Classification and properties, amino acids in sugarcane juice and molasses. Classification of carbohydrates, Examples and structures of various carbohydrates, Important carbohydrates for production of alcohol, beer and wine. Glycolysis, TCA cycle, Pentose Phosphate pathway, Glyoxylate cycle, Metabolism of amino acids. Definition, nomenclature, classification - (simple, complex, derived lipids - structure & example) phospholipids, glycolipids, - (structure, composition).

3.03 TC: Biochemistry of alcoholic fermentation

Pathways involved in alcoholic fermentation, Transport of carbohydrates in yeast. Inter relationship between sugar uptake during alcoholic fermentation (Pasteur and Crabtree Effect).

3.04 TN: Protein Synthesis

Definition, Structure of protein, Classification (Primary, Secondary, Tertiary, Quaternary- definition, examples) Types and functions of proteins, Biological importance, mechanism of protein synthesis.

3.05 TN: DNA and Chromosomes

DNA as the molecule of information: DNA as the genetic material and its organization. DNA structure, Purine, pyrimidine - definition and structure. Nucleoside, nucleotide: definition and structure. Chemical Properties: Hydrolysis

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(acid, alkali), enzymatic hydrolysis of DNA. DNA replication and its regulation. DNA damage and repair. Chromosomes: Structure and shapes of metaphase chromosomes histone, non histone proteins Nucleosome and packing of DNA into chromosome.

3.06 TN: Production of biogenic amines & ethyl carbamate

Usage & formation of sulphur compound. Microbial formation & modification of flavor & off-flavor compounds in wine. Exoenzymes of wine microorganisms.

Reference Books:

1. Biochemistry –Lehninger
2. Biochemistry – West and Todd
3. Wine Microbiology and Biotechnology- Graham H. Fleet.
4. Concepts on wine chemistry- the wine appreciation guide- Yair Margalit, James Crum.
5. Chemical analysis of grapes and wine techniques and concepts- Patrick ILAND, Nick BRUER, Andrew EWART, Andrew MARKIDES, John SITTERS.
6. The chemistry and biology of winemaking- Hornsey Ian.

WT 1.4 Practical-I

1. Morphological and anatomical studies of grapevines and sugar canes varieties and to note differences —3P
2. Field practicals on cultivation practices of grapevine and sugar canes such as pruning, grafting, spacing etc ----2P
3. Illustrated field exercises for harvesting and handling of grapevines –1P
4. Soil analysis : pH, temperature, soil texture, porosity, NPK, organic carbon, salinity, EC, soil moisture. (4P)
5. To collect infected samples and study the morphology of major pest and their life cycle 4P
6. Water Analysis: pH, alkalinity, hardness, chlorites EC, nutrients (3P)
7. Determination of Brix, Specific Gravity, pH of molasses
8. Determination of moisture and ash content of molasses.
9. Determination of total solids and suspended solids of molasses.
10. Determination the reducing sugar in final molasses.
11. Determination the total reducing sugar in final molasses.
12. Estimation of calcium content of molasses by EDTA method.
13. Determination of sludge content of molasses.

WT 1.5 practical-II

1. Preparation of culture media & sterilization.
2. Preparation of MGYP medium for growth & Identification of yeast.
3. Preparation of MGYP & molasses medium slants.
4. Enumeration of microorganisms by four-quadrant method.
5. Enumeration of microorganisms by using spread plate technique.
6. Counting of microorganisms by pour plate method.
7. Preparation of slide culture of yeast.
8. Negative staining and monochrome staining and Gram staining.

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9. Determination of nitrogen content by Kjeldahl's method.
10. Estimation of sugars by Arseno-molybdate method.
11. Determination of alcohol content by spectroscopic method.
12. Estimation of enzyme activities such as amalyse, glucoamylase (3P)
13. Estimation of proteins by Biuret and Lawry method (2P)
14. Determination of ethyl alcohol content of spirit by specific gravity method.
15. To determine the total sugars as invert sugars in final molasses.
16. Determination of total organic volatile acids of molasses.
17. Determination of total organic volatile acids of fermentation broth sample

Semester -II
WT 2.1 Alcohol Technology - I
Summary

| Credit No. | Credit title | Total hours per credit |
|------------|--------------------------------------------------|------------------------|
| 2.01 TC | Yeast maintenance and propagation in distillery | 15 |
| 2.02 TC | Raw material for alcoholic Fermentation | 15 |
| 2.03 TC | Details of alcoholic fermentation | 15 |
| 2.04 TN | Chemistry of alcohol | 15 |
| 2.05 TN | Alcohol based chemicals | 15 |
| 2.06 TN | Manufacturing of alcohol from various substrates | 15 |
| | | 75+15+90 |

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2.01 TC: Yeast maintenance and propagation in distillery

Design of yeast vessels, material of construction and its maintenance. Propagation practices of yeast adopted under plant conditions. Measurement of number of yeast cells/yeast count etc. Use of Bakers yeast. Active Dry yeast and yeast Acidification / pretreatment practices. Pre-fermentation practices adopted for yeast propagation prior to inoculation to main fermenter. Pre-fermenter (Blue) design; material of construction and its maintenance. Use of sterile air/sparging system in Pre-fermenter.

2.02 TC: Raw material for alcoholic fermentation

Overview of Molasses composition, grades, storage and cost. Details of molasses weighing system. Molasses dilution practices adopted and design of diluter, quality of dilution water used, Quality of water and molasses dilution practices. Pre clarification of molasses advantages and drawback, molasses sterilization/pasteurization.

2.03 TC: Details of alcoholic fermentation

Process of Batch fermentation, factor influencing efficiency of fermentation, characteristics of Batch Fermentation Process, Control over fermentation operation, contamination control, design and material of construction of fermenters, maintenance of fermenter and operational conditions on plant scale, flow sheet of Batch Fermentation process, Efficiency of Fermentation and Attenuation data calculations – Related examples and solutions. Alcoholmetry – proof spirit (British and USA) over proof, under proof, specific gravity of alcohol strength of alcohol in terms of concentration – related examples and solution. Prevention of losses of alcohol during fermentation, post – fermentation practices/scrubbing etc.

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2.04 TN: Chemistry of alcohol

What is alcohol? Physical and chemical properties of alcohol; Classification of alcohols, Important chemical reactions of alcohol; Production of alcohol by synthetic method. Uses of alcohol.

2.05 TN: Alcohol based chemicals

Detail study of reactions involved, manufacturing process, uses, list of manufacturers-Acetaldehyde, Acetic acid, Acetic-Anhydride, Butanol, Ethyl acetate, Butyl acetate, acetone, Ethyl ether, Diethyl oxalate.

2.06 TN: Manufacturing of alcohol from various substrates

Introduction to various substrates used for alcohol production. Details of alcohol yield using sugarcane and sugar beet molasses, rice, maize, sorghum, bajara, wheat, dates, cashew apple, etc.

Reference Books:

1. The Alcohol Textbook – Jacques, T. P. Lyons & D. R. Kelsall
2. Alcoholometry – Satyanarayana Rao
3. Handbook of Fermentation and Distillation – A.C. Chatterjee
4. Distillation – H. C. Barron
5. Technical Excise Manual
6. Byproducts of Sugar Industry – Paturao

**WT 2.2 Brewing Technology-I
Summary**

| Credit No. | Credit title | Total hours per credit |
|------------|-----------------------------------------------|------------------------|
| 2.01 TC | History and overview of Industrial Brewing | 15 |
| 2.02 TC | Beer origin, classification and beer styles | 15 |
| 2.03 TC | Basic raw materials of brewing | 15 |
| 2.04 TN | Overview of world and Indian brewing scenario | 15 |
| 2.05 TN | Hop products | 15 |
| 2.06 TN | Alcoholism | 15 |
| | | 75+15=90 |

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Teaching clock hours = 60 clock hours and**
- 3) **Total clock hours per course= 75+15=90 clock hours**

2.01 TC: History and overview of Industrial Brewing

Introduction, Brewing in an Agrarian World, The Eighteenth century: Porter: The First Industrial Beer. Mechanization & Measurement, The Nineteenth Century: Porter Vs Ale, the rush to bottom fermentation, science & practice. The Twentieth Century: Beer and Society, Temperature and prohibition. Consumer choice Fewer & Bigger: The path to Globalization, Science Applied & Technology Transformed. An overview of Brewing: Introduction, outline of the Brewing steps, Malting, Milling and Adjunct Use, Mashing, Wort separation, Wort boiling, Trub removal, Wort cooling/Aeration, Yeast handling, Yeast pitching, Fermentation, Yeast removal, Aging, Clarification, packaging and warehouse practices.

2.02 TC: Beer origin, classification and beer styles

Their origins and classification-Introduction: How different styles are created, Factors involved in styles of Beer, Ingredients: Water, fermentable carbohydrates, Hops yeast, Processing: Equipment configuration, milling, mashing Lautering, Boiling time, Fermentation Temperature, Maturation time, filtration, Packaging, Marketing, Cultural Origins of style, Analytical and Sensor variables, Beer style guidelines, analysis, tasting &, Brewing Beer. The Beer Styles-Ales British Origin, Irish Original, German Origin, Belgian and French Origin, Lager Beer, European-Germanic origin, North American Origin, Other Origin.

2.03 C: Basic raw materials of brewing

Water: Water usage in the Brewery, Brewery water consumption, Brwery water Calgary's: Brewing water, process water, General-purpose water, service water, water standards for ingredient use. Chemical Characterization of water types, Microbial constituents of water, the influence of inorganic ions from water on Beer Quality, ingredient effect of ions on Beer flavor and quality, control of pH, water treatment systems.

Barley and Malt: - Barley – Structure and function, the husk the pericarp, testa, Aleurone Layer, Starchy Endosperm, The Embryo.

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Malt Production, Drying, Storage, and Handling, steeping, Germination, Kilning and Malt Quality, Malt varieties.

Adjuncts: Introduction, Corn Grits, Rice, Barley, Sorghum, Refined Corn Starch, wheat starch, Terrified cereals, liquid adjuncts, Malt from cereals other than Barley. Wheat Malt, Oats and Rye Malt, Sorghum, Conclusions.

Hops: Hop Growing, History, Hop Growing today, the hop plant, Hop classification, Hop cultivation, Harvesting, drying and packing, Hop varieties.

2.04 TN: Overview of world and Indian brewing scenario

Global brewing scenario, Major beer manufacturing companies in the world and major brands. Statistics of production and per capita consumption of beer in various countries. Indian brewing scenario and scope for brewing industry in India.

2.05 TN: Hop products

Hops- Hop chemistry, whole Hops, Hop Resins, Soft Resins, Hard Resins, Hop oils, Hop storage, Hop variety, Hop oils, Hop resin acids, Bittering value, Bitter flavor and foam – Role of α -acids, Reduced Iso α -acids, The “Light struck” Reaction, Inhibition by reduction.

Hops and hop products. Manufacture of reduced Iso- α -acids Hop products, Development of Hop products, Benefits of Hop products. Optimization of hops addition in propagation of brewing yeast and brewing process. Typical chemical profile in presence and absence of hops. Factors affecting on hop addition in brewing process.

2.06TN: Alcoholism

What is alcoholism? Effects of alcohol on human being-Health issues, social issues and economical issues. Concept of responsible drinking. Alcohol unit, measurement of alcohol units in various alcoholic beverages.

Reference Book:

1. American Society of Brewing Chemists, U.S.A.: Methods of analysis of American society of brewing chemists. (8th rev.) U.S.A. American society of brewing chemists, 1996.
2. Arntzen,C.J.,ed.: Encyclopedia of agricultural science, vol. 1: - A - D. N. York, Academic Press, 1994.
3. Birch,G.G.: Alcoholic beverages. London, Elsevier Applied Science Pub.1985.
4. Government of India. Technical Excise Manual. --(663.16GOV)
5. Hardwick,W.A.,ed.: Handbook of brewing. N. York, Marcel Dekker,Inc.,1995.(663.3 HARHAR)
6. Hough,J.S.,Briggs,D.E.,Stevens,R.,Young,T.W.: Malting & brewing science, vol. 2 : hopped wort & water. London, Champman & Hall, 1982.
7. Pollock, J.R.A., and ed.: Brewing science vol. 1.London, Academic Press, 1979, (663.3POL)
8. Pollock, J.R.A., and ed.: Brewing science, vol. 2. London, Academic Press, 1981. (663.3POL)
9. Prescott, S.C. & Dunn, C.G.: Industrial microbiology. Jodhpur. Agrobios (India), 2002. 81-7754-149-8
10. Priest, F.G.: Brewing microbiology, 2nd ed.. (1996) U.K. Chapman & Hall, 1996. 0412591502--(576PRI)

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11. Priest, Fergus G.; & Stewart, Graham G.: Handbook of brewing. (2nd) U.S.A. CRC Press, Taylor & Francis Group, 2006.

**WT 2.3 Enology-I
Summary**

| Credit No. | Credit title | Total hours per credit |
|------------|----------------------------------------------------------------------------------|------------------------|
| 3.01 TC | History and classification of wine | 15 |
| 3.02 TC | Wine making processes | 15 |
| 3.03 TC | Clarification, stabilization, preservation, maturation and fortification of wine | 15 |
| 3.04 TN | Overview of world and Indian wine scenario | 15 |
| 3.05 TN | Nutritional and health aspects of Wine | 15 |
| 3.06 TN | Pot distillation of wine | 15 |
| | | 75+15=90 |

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Teaching clock hours = 60 clock hours and
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1.01 TC: History and classification of wine

Introduction: History of wine making, present international and national status of wine production and wine market, scope and importance of wine industries, nutritional and therapeutic value of wine, commercial aspect of wine production. Classification of wine- table wines, sparkling wine, dessert wines, aperitif wine, pop wine.

1.02 TC: Wine making processes

Red wine production-time of harvest, harvesting, crushing & fermentation, blending; White wine production- White wine styles, harvesting, crushing, pressing, settling/clarification & fermentation. Manufacturing of fruit wine from pomegranate, banana, jamun, etc. Manufacturing of apple, pear ciders, Sparkling wine- The Champagne method, the tank method, the transfer method, carbonation; cold maceration; carbonic maceration; thermo vinification; chaptalisation; use of commercial enzyme in wine making. Monitoring and controlling of fermentation parameters of wine: monitoring and viability and cell number of yeast during must preparation, controlling microbial growth during wine production, effect of pH, temperature, CO₂, amount of sugar consumed. Use of Destemer/crusher, Pneumatic press, Fermenter, Cooling system, Kielsgur filter, Seitz filter, Cold stabilizer, Bottling machine and neck freezing machine.

1.03 TC: Clarification, stabilization, preservation, maturation and fortification of wine

Clarification & stabilization of wine- Clarification- proteins, polyvinyl polypyrrolidone & bentonite; Tartaric acid, tartarate & wine stability- static cold stabilization, contact cold stabilization, ion exchange stabilization, estimation of cold stability, prevention of crystallisation, protein instability, assessment of heat

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(protein) stability. Preservation of wine- sulphur dioxide, dimethyl dicarbonate, sorbic acid & benzoic acid. Maturation & aging- Sur Lie storage of wine, Oak Barrel & wine, maturation reactions in red wine, Micro-oxygenation, corks. Fortified wines- Fortification, port, Vins Doux Naturels (VDN), Madeira, Sherry, Commandaria.

1.04 TN: Overview of world and Indian wine scenario

New concept of wine production: organic, biodynamic wine, Ice wine, etc. Major wine producing countries in the world, Per capita consumption and production statistics of wine production of major top wine manufacturing countries in the world. The current and future wine prospectus in India.

1.05 TN: Nutritional and health aspects of wine

Chemical contents of grapes and wine in relation to nutrition, Contribution of important chemicals at human health point of view, List of diseases cured by wine, Role of antioxidants of wine on human health. Comparison of Red, white and sparkling wine at nutritional point of view.

1.06 TN: Pot distillation of wine

Details of pot distillation, Manufacturing and maturation of grape spirit, Production of brandy, Cognac, Legal attributes of production and marketing of Cognac.

Reference Book:

1. Handbook of Enology, Vol. I. The Microbiology of Wine and Vinification- P. Ribereau- Gayon, D. Dubourdieu, B. Doneche, A. Lonvaud.
2. American Society for Enology and Viticulture- Seattle.
3. Australian Society of Viticulture and Enology - Andrew Markides, Richard Gibson.
4. Introduction to winemaking, Viticulture and Enology 3- Prof. Ralph E. Kunkee.
5. Understanding wine- Course notes- Patrick Iland, Peter Gago.
6. Wine science- Ron S. Jackson.
7. Handbook of Enology, Vol 2- The chemistry of wine stabilization and treatments- P. Ribereau – Gayon, D. Dubourdieu, A. Maujean, Y. Glories.
8. Concepts on wine chemistry- the wine appreciation guide- Yair Margalit, James Crum.
9. Wine making from grape growing to marketplace- Richard P. Vine, Ellen M. Harkness, Salley J. Linton.
10. Monitoring the wine making process from grapes to win techniques and concepts- Patrick ILAND, Nick BRUER, Andrew EWART, Andrew MARKIDES, John SITTERS.
11. Wine appreciation- Richard P. Vine.

**WT 2.4 Chemical and Plant Engineering-I
Summary**

| Credit No. | Credit title | Total hours per credit |
|------------|---------------------------------------------------|------------------------|
| 4.01 TC | Principles of distillation | 15 |
| 4.02 TC | Utility requirements for typical distillery | 15 |
| 4.03 TC | Pressure, Flow, Temperature and Level measurement | 15 |
| 4.04 TN | Refractometry, Polarimetry | 15 |
| 4.05 TN | Fuels and combustion | 15 |
| 4.06 TN | Plant Automation | 15 |
| | | 75+15=90 |

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Part I: Chemical and Plant Engineering

4.01 TC: Principles of distillation

Principles of distillation Vapour liquid equilibrium, boiling point, and diagram. Basic principle of distillation, Pot and coffee stills conventional/ continuous distillation system. Introduction study of elementary chemical engineering concepts. Classification of chemical process. Material balance with and without chemical reaction, process calculation involving various unit operations.

Heat transfer fundamentals

Types of heat exchange, design of heat exchange equipments and their application to distillery industry.

4.02 TC: Utility requirements for typical distillery

Steam Generation, Characteristics of steam, use of steam to process industry, introduction and types of boilers. Engineering materials- types of materials, their properties and uses. Power requirement for typical unit. Power generation through steam turbine.

Reference Books:

1. Introduction to Chemical Engineering – Badger and Baneo
2. Introduction to Chemical Engineering – Ghosal & Sanyal
3. Stoichiometry – Bhatt and Vora

Part -II Instrumentation

4.03 TC: Pressure, flow, temperature and flow measurement

Introduction to Instrumentation, important terms associated with instruments such as range, span, accuracy, error, resolution, accuracy, reproducibility, repeatability, and sensitivity. Various pressure units and their conversion, pressure transducers such as barometer, manometers, Bourdon tube, diaphragm, bellows, capsule, strain gauges for pressure measurement.

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Flow measurement

Basic terms such as total flow, volumetric flow, Mass flow, types of flow, flow transducers such as orifice plate, pitot tube, flow nozzle venturi meter, variable area flow meter, magnetic flowmeter, coriolis mass flow meter, vortex flowmeter, ultrasonic flowmeter, turbine flowmeter, displacement flowmeter.

Temperature measurement

Various scales and conversion, Introduction to filled system thermometers, expansion thermometers, thermocouples, Resistance temperature detector, Thermistors and pyrometers.

Level measurement

Direct methods such as gauge glass method, float method, magnetic level indicator, magnetic level switches, indirect methods such as hydrostatic method, radiation method, ultrasonic method and capacitance method.

4.04 TN: Refractometry, polarimetry:

Refractive index, Hand refractometer, Abbe's refractometer. pH and conductivity measurement - Introduction, different types of sensors, pH meter and conductivity meter.

Polarimetry

Laurentz polarimeter, industrial polarimeter, white lamp single wedge/double wedge polarimeter, automatic polarimeter.

4.05 TN: Fuels and combustion:

Classification of fuels, gross & net calorific value, principles of combustion. Power generation and utilization, sources of power generation, Classification of turbines, Basic principles of Electrical Engineering. Pumps and their application, characteristic curves, types of pumps, (maintenance of pumps and operation). Use of compressed air for process industry, compressor and its working principles. Fluid flow fundamentals. Laminar and turbulent flow. Bernoulli's theorem and its applications, Friction factor pump selection and applications.

4.06 TN: Plant Automation:

Different systems used for automation. Details of PLC, SCADA and DCS monitoring systems. Benefits of automation.

Reference Books:

1. Instrument Engineers handbook – Process measurement by BG Liptak
2. Process Instrumentation & Control by A. P. Kulkarni
3. Process Control Instrumentation Technology by C. D. Johnson.
4. Instrumental methods of analysis by Willard, Merrit & Dean.

WT 2.5 Practical- I

1. Sampling & grading of barley.
2. Preparation of sample of barley for chemical analysis.
3. Determination of Moisture & Extract content of barley.
4. Study of germination of barley.
5. Determination of Specific Gravity & Extract of wort.
6. Determination of Reducing sugar content of wort.
7. Determination of Fermentable saccharides of wort.
8. Determination of pH & acidity of wort.
9. Sampling & physical tests of malt.
10. Determination of moisture content of malt.
11. Determination of extract content of malt.
12. Determination of ethanol content of spirit sample by oxidation method.
13. Determination of fermentation efficiency of yeast growing on molasses medium.
14. Determination of total & fixed volatile acidity of rectified spirit (ISI method)
15. Determination of volatile acidity of rectified spirit (ISI method)
16. Determination of aldehyde content of Rectified Spirit (AOAC Method)
17. Determination of ester content of Rectified Spirit (AOAC Method)
18. Determination of fusel oil content in spirit sample.
19. Determination of furfural content in spirit sample.
20. To conduct potassium permanganate test for finding the quality of spirit.
21. Determination of fermentation efficiency of yeast growing on molasses medium.
22. Preparation of wine from grapes.
23. Determination of total reducing sugar of wine production.
24. Determination of pH & total acidity of wine.
25. Determination of Volatile acidity of wine by Sellier's method.
26. Determination of free & total Sulphur dioxide of wine.

M. Sc. -II
Semester-III
WT 3.1 Alcohol Technology - II
Summary

| Credit No. | Credit title | Total hours per credit |
|------------|-----------------------------------------------------------------------------------------------------------|------------------------|
| 1.01 TC | Characteristics of various alcohols, denaturation and by-products of alcohol industry | 15 |
| 1.02 TC | Manufacture of Extra Neutral Alcohol, Anhydrous alcohol/Fuel ethanol | 15 |
| 1.03 TC | Reduction, blending and alcoholic beverages | 15 |
| 1.04 TN | Analytical aspects of alcohol and alcoholic beverages; Overview of distillery industry in India and world | 15 |
| 1.05 TN | Making of various traditional beverages | 15 |
| 1.06 TN | Importance of thermotolerant and osmophilic yeast in alcohol industry | 15 |
| | | 75+15=90 |

Note:

- 1) 3 TC Credits and any 2 Credits from TN.
- 2) The subject covers total 5 Credits i. e.
Teaching clock hours = 60 clock hours and
- 3) Total clock hours per course= 75+15=90 clock hours

1.01 TC: Characteristics of various alcohols, denaturation and by-products of alcohol

Composition of Wash, RS, EQRS, ENA, EQENA, FA, AA and IS. Denaturation of spirit – Denaturing agents O.D.S, S.D.S., ware house practices – Excise Rules & Regulations. Distillation – Atmospheric distillation process and its operation & maintenance, Specifications of plant and machinery. By products of alcohol manufacture – CO₂, fusel oil & yeast sludge.

1.02 TC: Manufacture of Extra Neutral Alcohol, Anhydrous alcohol/Fuel ethanol.

Process details, utilities requirement, specifications of ENA, quality aspect, specifications of plant and machinery. Azeotropic mixture commercial production of ethanol by azeotropic distillation. Distillation efficiency, Effect of traces of entrainer (benzene, cyclohexane, monoethylene glycol) on fuel ethanol.

Rules with examples, Maturation and Aging of spirit: Factors influencing alcoholic fermentation.

1.03 TC: Reduction, blending and alcoholic beverages.

Alcoholic beverages-Classification of beverages, liquor, country liquor manufacturing process. Quality control aspects. Global practices for manufacturing of IMFL. Maturation and aging: changes during maturation (spirit characters, aroma, flavor etc). Types of wood used for cask/barrel making. Typical design of barrel Role of excise in CL and IMFL. Shelf life of alcoholic beverages.

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1.04 TN: Analytical aspects of alcohol and alcoholic beverages

Overview of IS and international standards of molasses, various alcohol and alcoholic beverages. Proper sampling of spirit samples for analysis. Introduction to important Global organizations in all over the world involved in analysis of spirit and beverages.

Overview of distillery industry in India and world

1.05 TN: Making of various traditional beverages

Introduction to making of grain based popular beverages in the world. Indian rice beer (Pachwai), Bhaati Jaanr, Chhang (Lugri, Jhol, Chakti, Ghanti), Themsing, Rakshi, Mingri, Lohpani, Bhangchang, Apong, Sekete, etc.

1.06 TN: Importance of thermotolerant and osmophilic yeast in alcohol industry

Basic mechanism of thermotolerant and osmophilic yeast, the factors determining and affecting stress of thermotolerance and osmophilic, Industrially important strains for alcohol fermentation and beneficial aspects to industry.

Reference Book:

1. The Alcohol Textbook – Jacques, T. P. Lyons & D. R. Kelsall
2. Alcoholometry – Satyanarayana Rao
3. Handbook of Fermentation & Distillation – A.C. Chatterjee
4. Distillation – H.C. Barron
5. Technical Excise Manual
6. Byproducts of sugar industry – Paturao

**WT 3.2 Brewing technology-II
Summary**

| Credit No. | Credit title | Total hours per credit |
|------------|----------------------------------------------|------------------------|
| 2.01 TC | Yeast metabolism and brewhouse technology | 15 |
| 2.02 TC | Control of brewing process | 15 |
| 2.03 TC | Packaging and sanitation aspects in brewery | 15 |
| 2.04 TN | Brewery by - products and waste valorization | 15 |
| 2.05 TN | Quality management systems | 15 |
| 2.06 TN | Malt analysis | 15 |
| | | 75+15=90 |

Note:

- 1) 3 TC Credits and any 2 Credits from TN.
- 2) The subject covers total 5 Credits i. e.
Teaching clock hours = 60 clock hours and
- 3) Total clock hours per course= 75+15=90 clock hours

2.01 TC: Yeast metabolism and brewhouse technology

Life cycle and Genetics: Vegetative reproduction, Genome strain improvement, killer yeast, Genetic manipulation Nutritional Requirements: Oxygen requirements, Lipid metabolism, Uptake and metabolism of wort carbohydrates, Maltose uptake. Uptake and Metabolism of wort Nitrogen, Yeast Extraction Products: Alcohols, Esters, sulfur compounds carbonyl compounds, Diacetyl and Pentane-2, 3-dione Flocculation – Glycogen & Trehalose – The yeast carbohydrate storage polymers. Pure Yeast Cultures:

Introduction, strain selection, storage of cultures propagation & scale up, contamination of cultures, Yeast washing, yeast pitching & cell viability, yeast collection, yeast storage, shipping of yeast.

Brewhouse Technology: Introduction, General layout of Brewhouse, Heat transfer in the Brewhouse – Heat transfer, materials, Raw Materials Intake: Storage, Removal of foreign objects, Milling: Reasons for milling, Roll mills, Roll milling with conditioning low pressure steam conditioning, Hot water conditioning. Wet milling, wet milling with steep conditioning, Hammer milling, Mash conversion and separation: - Purpose of mashing, Basic principles of mash separation, Mash tuns, mashing – systems, The mash conversion vessel, Adjunct or Cereal Cookers, Mash Kettle, Mash acidification, Mash separation systems – Lauter Tuns, strain master, mash filters, membrane mash filters, The Nortek Mash filters, comparison of separation systems. Wort Boiling – principles of Boiling, Types of Boiling, Objective, Wort preventing, types of wort boiling systems, Energy recovery systems in the Brewhouse, Hop addition, wort clarification – separation systems, wort cooling and Aeration, plate and frame Heat Exchangers. Removal of cold break, cold sedimentation tank, anstellbottich, centrifugation, filtration, floatation, aeration, yeast addition, Brewhouse efficiency – brewhouse yield, Brewhouse capacity, Brewhouse cleaning.

2.02 TC: Control of brewing process

Introduction, process performance, Brewhouse unit operations, Grist preparation – Malt cleaning, Malt weighing, malt milling – Grist particle size distribution, Grist storage, dust extraction and dust explosion prevention malt silo-level detection and stock control, Grain flow and Routing, Mashing:- Grist transfer, water flow & temperature Mash homogeneity, mash heating, temperature control, vessel level control, conversion efficiency, Wort separation: Mash transfer. Wort filtration, sparging, effluent, spent grain, extract yield to kettle, Wort Boiling:- Nucleate Boiling Evaporation rate, Level control Avoidance of boil over, liquid adjunct metering, Hops addition and utilization, volatile stripping, trub formation, Hot wort clarification and cooling:- Hot wort clarification wort cooling, wort flow rate, wort temperature, turbidity and cold break, conductivity, wort oxygenation, trub handling and wort recovery, Brewhouse yield.

Fermentation: Wort: - Clarification, Aeration laboratory analyze, Pitching – Microbial examination, cell concentration and pitching, pitching process. Metabolism & growth – biochemistry of fermentation, growth during fermentation, measurement of growth. Batch fermentations, Lager fermentation, fermentation vessels, characteristics of fermentation, Ale fermentation, Laboratory analysis during fermentation, factors affecting fermentation, yeast strain and condition, pitching rate and yeast growth, temperature, oxygen, zinc, trub canny over, fermenter geometry, interrelationship, Related fermentations: High gravity fermentations, accelerated fermentations, High-pressure fermentations, Continuous fermentations, low caloric fermentation:- Definition production methods, Nonalcoholic and low alcohol fermentation – Definitions, major deficiencies, production methods, Immobilized yeast, Abnormal Fermentations – Symptoms causes – process variations , wort nutrient deficiencies yeast changes. Treatments, Beer transfers and yeast separation – yeast cropping consideration, method of cropping – centrifugation, Recovery of carbon dioxide – purity and collection strategies.

Aging and Finishing: Introduction, Objectives of Aging and Finishing, component processes flavor maturation: - Impart flavor compounds Diacetyl and 2, 3-pentanedione, sulfur compounds, non-volatile flavor maturation, yeast autolysis Lagering and secondary fermentation (Kransening) Historical Lagering Practice, Krausening, lagering without secondary fermentation, addition of modified Hop extracts. Beer Recovery: Economics, Quality of recovered beer. Clarification: - Gravity sedimentation, finings, filtration, filters, sterile filtration. Stabilization: Beer Stability: Biological and Non-biological Instability. Biological Instability, Non biological stability: Physical stability, Flavor stability foam stability, Gushing, light stability, Flavor stability, Biological stability, Physical stability, Carbonation: - Basics of beer carbonation, modern carbonation, Standardization.

2.03 TC: Packaging and sanitation aspects in brewery

Packaging Technology: Levels of packaging, packaging materials, packaging and brewing industry, cost of packaging, glass bottles and bottling, bottle filling, PET bottles, cans, Kegs and Kegging, Pasteurization, Tunnel Pasteurization packaging line efficiency. Introduction to CIP.

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Sanitation and Pest Control: Types of pest encountered, integration of sanitation and pest control methods, possible points of contamination, insects control methods, insect monitoring method, safety.

2.04 TN: Brewery by - products and waste valorization

Composition and feed value of major brewery by-products and competitive feeds, Brewhouse effluent, spent Hops and Trub. Wet Brewers Grain Handling and Dewatering, Brewers Grain Drying, Brewers grain Feed Products. Brewers yeast, Brewers condensed soluble, excess carbon dioxide, spent filter cake.

2.05 TN: Quality management systems

Quality management systems, ISO 9000, Hazard Analysis critical control point, customer requirements, material control, analytical control, customer and consumer feedback, process control.

2.06 TN: Malt analysis

System of analysis of malt, Common analysis –Hot water extract, cold water extract, Moisture content, Distatic power, Dextrinising units, Colour, Fermentable extract, Friability and homogeneity.

Reference Book:

1. American society of brewing chemists, U.S.A.: Methods of analysis of American society of brewing chemists. (8th rev.) U.S.A. American society of brewing chemists, 1996. 1-881696-01-4--(AME)
2. Arntzen,C.J.,ed.: Encyclopedia of agricultural science, vol. 1: - A - D. N. York, Academic Press,1994., Rs.18802.00--(630.3 ARNARN)
3. Birch G.G.: Alcoholic beverages. London, Elsevier Applied Science Pub.,1985., Rs.369.20--(663.1BIR)
4. Government of India.: Technical Excise Manual. --(663.16GOV)
5. Hardwick,W.A., ed.: Handbook of brewing. N.Y ork, Marcel Dekker,Inc.,1995., Rs.6181.50--(663.3 HARHAR)
6. Hough,J.S.,Briggs,D.E.,Stevens,R.,Young,T.W.: Malting & brewing science, vol. 2 : hopped wort & water. London, Champman & Hall, 1982. Rs.591.50- (663.3HOU)
7. Pollock, J.R.A., and ed.: Brewing science vol. 1.London, Academic Press, 1979, Rs.7046.80-- (663.3POL)
8. Pollock, J.R.A., and ed.: Brewing science, vol. 2. London, Academic Press, 1981., Rs.7046.80--(663.3POL)
9. Prescott, S.C. & Dunn, C.G.: Industrial microbiology. Jodhpur. Agrobios (India), 2002, 81-7754-149-8.
10. Priest, F.G.: Brewing microbiology, 2nd ed.. (1996) U.K. Chapman & Hall, 1996. 0412591502--(576PRI)
11. Priest, Fergus G.; & Stewart, Graham G.: Handbook of brewing. (2nd) U.S.A. CRC Press, Taylor & Francis Group, 2006. 0-8247-2657 x

**WT 3.3 Enology- II
Summary**

| Credit No. | Credit title | Total hours per credit |
|------------|--------------------------------------------------------------------------------|------------------------|
| 3.01 TC | Role of various microbes in enology | 15 |
| 3.02 TC | Rapid detection of microbial spoilage in wine process | 15 |
| 3.03 TC | Sensory analysis and tasting of wine | 15 |
| 3.04 TN | Marketing aspects of wine and brand development | 15 |
| 3.05 TN | Packaging of wine and standards/guidelines/certification in wine manufacturing | 15 |
| 3.06 TN | Concept of wine parks | 15 |
| | | 75+15=90 |

Note:

- 1) 3 TC Credits and any 2 Credits from TN.
- 2) The subject covers total 5 Credits i. e.
Teaching clock hours = 60 clock hours and
- 3) Total clock hours per course= 75+15=90 clock hours

3.01 TC: Role of various microbes in enology

Lactic acid bacteria- Introduction, Ecology & physiology of lactic acid bacteria; physical & chemical stress factor in LAB; Activities in must & wine; LAB & malolactic fermentation- Urethane & arginine metabolism; Characteristic of genera and species of wine related LAB- *Lactobacillus*, *Leuconostoc*, *Oenococcus*, *Pediococcus*, *Weissella*. Acetic acid bacteria- Introduction, Isolation & taxonomy, AAB in grapes & musts, fermentation, During aging & wine maturation, Acetic acid bacteria & wine spoilage. Fungi of grapes- Introduction, *Peronosporomycetes*, *Ascomycetes*, *Botrytis*, *Zygomycetes*. Phages of yeast & Bacteria- Killer yeast and wine fermentation, Viral infection, viral preprotoxin processing & toxin maturation, phages in wine & malolactic conversion.

3.02 TC: Rapid detection of microbial spoilage in wine process

Impedimetric techniques (Conductance, capacitance), Microcalorimetry, Turbidometry, Flow cytometry, Microcolony method, direct epifluorescence filter technique. Methods for the rapid identification of microorganisms. PCR, Wine spoilage- introduction; spoilage microorganism; Wine faults. Production technology of Wine from fruits other than the grapes, application of colour & additive in grape wine production.

3.03 TC: Sensory analysis and tasting of wine

Wine tasting- Smell of wine, taste & colour of wine, sensory analysis of wine. Factors affecting on sensory analysis. Sensory analysis profile of white, red and sparkling wine. Sensory analysis profile of day to day fermented young wines and comparison with old wines.

3.04 TN: Marketing aspects of wine and brand development

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Ideal packaging of wine bottle, The question of age, the private wine cellar, serving temperature, decanting wines, which glass for which wine, serving wine, how to open & serve sparkling wines, Corkscrews.

3.05 TN: Packaging of wine and standards/guidelines/certification in wine manufacturing

Principles and methodology involved in analytical techniques of wine analysis, Application of various analytical instruments used in wine analysis.

Definition of quality, quality assurance, importance of quality control & assurance, role of quality control department in wineries, Different factors affecting the wine quality, quality criterion of different wines etc.

Standards of various types of wine and safety management system for winery. Different rules, regulation and laws for wine and wine manufacturing/ wineries. (GLP, PFA, BIS, CODEX standards, JECFA, HACCP, ISO, Global/European guidelines, Food Safety and Standards Act, 2006 etc.).

Recent developments in wine packaging and government regulations in various countries. Packaging technology, labeling & storage of wines; Economics aspects of packaging-economic feasibility studies of wine packaging.

3.06 TN: Concept of wine parks

Concept of wine parks recent developments. Wine parks & nodal agencies for establishment of Wine Park in India. Status of wine parks in India with reference to case study. Important wine zones in India.

Reference Book:

1. Handbook of Enology, Vol. I. The Microbiology of Wine and Vinification- P. Ribereau-Gayon, D. Dubourdieu, B. Doneche, A. Lonvaud.
2. American Society for Enology and Viticulture- Seattle.
3. Australian Society of Viticulture and Enology - Andrew Markides, Richard Gibson.
4. Introduction to Winemaking, Viticulture and Enology 3- Prof. Ralph E. Kunkee.
5. Understanding wine- Course notes- Patrick Iland, Peter Gago.
6. Wine science- Ron S. Jackson.
7. Handbook of Enology , Vol 2- The chemistry of wine stabilization and treatments- P. Ribereau – Gayon, D. Dubourdieu, A. Maujean, Y. Glories.
8. Concepts on wine Chemistry- the wine appreciation guide- Yair Margalit, James Crum.
9. Wine making from grape growing to marketplace- Richard P. Vine, Ellen M. Harkness, Salley J. Linton.
10. Monitoring the wine making process from grapes to win techniques and concepts- Patrick ILAND, Nick BRUER, Andrew EWART, Andrew MARKIDES, John SITTERS.
11. Wine appreciation- Richard P. Vine.
12. Wine technology marketing- Mary Cole.

WT 3.4 Chemical & Plant engineering –II
Summary

| Credit No. | Credit title | Total hours per credit |
|------------|----------------------------------------|------------------------|
| 3.01 TC | Mass balance and Separation techniques | 15 |
| 3.02 TC | Heat transfer | 15 |
| 3.03 TC | Thermodynamics | 15 |
| 3.04 TC | Fluid mechanics | 15 |
| 3.05 TN | Psychometric | 15 |
| 3.06 TN | Design of distillation column | 15 |
| | | 75+15=90 |

Note:

- 1) 3 TC Credits and any 2 Credits from TN.
- 2) The subject covers total 5 Credits i. e.
Teaching clock hours = 60 clock hours and
- 3) Total clock hours per course= 75+15=90 clock hours

3.01 TC: Mass balance and Separation techniques

Single and multiple unit processes, Reactive systems, Purge systems, Recycle, Bypass systems.

Separation techniques like sedimentation, filtration & centrifugation: basic principles & equipments. Membrane separations & their applications.

3.02 TC: Heat transfer

Conduction, convection, thermal resistance and heat flux, Types of heat exchangers, Nucleate boiling curves, calculation of boiling heat flux, Vapor compression, Heat efficiency, Heat transfer through flat and curved surfaces and effects of insulation and its efficiency.

3.03 TC: Thermodynamics

Gases and their properties, Vapor pressure, Gibbs phase rule, Ideal gas law, Equation of state compressibility factor, Energy balances specific and latent heat, Enthalpy, Entropy, Internal energy heat and work, Open and closed systems, Thermodynamic diagrams, power and refrigeration.

3.04 TN: Fluid mechanics

Fluid static, fluid dynamics, flow measurement, pipe/duct flow. Frictional pressure losses in pipe/duct, flow pumps/fans, cavitations, net pressure, suction head, Flow of fluid in pipes, and through pump in brewery setting.

3.05 TN: Psychometric

Heating, cooling, humidification, dehumidification, mixing of air streams, drying of cereals and food as psychometric process.

3.06 TN: Design of distillation column

Calculation of number of plates using McCabe Thioale method. Design of distillation column.

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Reference Books:

1. Introduction to Chemical Engineering – Badger and Baneo
2. Introduction to Chemical Engineering – Ghosal & Sanyal
3. Stoichiometry – Bhatt and Vora
4. Process control systems by F.G. Shinskey
5. Process Control Instrumentation Technology by C. D. Johnson.
6. Applied Instrumentation in the Process Industries by W.G. Andrew and H.B. Williams

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WT 3.5 Practical

1. Determination of residue on evaporation of whisky sample.
2. To carry out distillation of whisky sample
3. Determination of ethyl alcohol content of whisky by specific gravity method
4. Determination of Total acidity as acetic acid of whisky
5. To determine the volatile acidity whisky sample.
6. Determination of Aldehyde(as CH_3CHO) content of spirit (AOAC method)
7. Determination of Ester(as $\text{CH}_3\text{COO C}_2\text{H}_5$)content whisky
8. Fusel oil determination in spirit sample
9. Furfural determination in Rectified Spirit (ISI)
10. Determination of Methyl Alcohol (as CH_3OH) content of whisky
11. Reduction of the spirit
12. Blending of spirit
13. Preparation of sample of barley for chemical analysis
14. To determine moisture content of the barley
15. To determine the extract content of barley
16. Propagation of yeast in laboratory (Demonstration experiment)
17. Analysis of alcohol by Gas Chromatography (Demonstration experiment).
18. Determination of starch content in grain flour sample.
19. Alcohol production from corn/sorghum/sweet potato (Demonstration experiment)
20. Estimation of hop bitterness and colour of beer.
21. Detection of microbial contamination in beer.

Semester-IV
WT 4.1 Business Management: (BM)

Summary:

| Credit No. | Credit title | Total hours per credit |
|------------|------------------------------------------------------------------------------------|------------------------|
| 1.01 TC | Financial management and Financial analysis | 15 |
| 1.02 TC | Financial control & management information system | 15 |
| 1.03 TC | Cost accountancy and working capital management | 15 |
| 1.04 TN | Analysis of financial parameters for setting up of industry & its appraisal report | 15 |
| 1.05 TN | Maintenance Management, Inventory planning and Inspection | 15 |
| 1.06 TN | Value engineering, production, planning and control | 15 |
| | | 75+15=90 |

Note:

- 1) 3 TC Credits and any 2 Credits from TN.
- 2) The subject covers total 5 Credits i. e.
Teaching clock hours = 60 clock hours and
Total clock hours per course= 75+15=90 clock hours

1.01 TC: Financial management and Financial analysis

Definition, objectives, functions & scope. Details of financial analysis and management.

1.02 TC: Financial control & management information system

Definition, objectives, functions & scope. Funds flow analysis, Ratio analysis, Cost profit volume analysis.

1.03 TC: Cost accountancy and working capital management

Concept, dimensions and operating cycle of business.

1.04 TN: Analysis of financial parameters for setting up of industry & its appraisal report.

1.05 TN: Maintenance Management, Inventory planning and Inspection

Importance and types of maintenance, spare part maintenance and concept of TPM. Inventory planning and control, E.O.Q and numerical on E.O.Q.

Inspection: Cent percent Inspection, Random Sampling, Introduction to Six Sigma, Seven tools of quality control.

1.06 TN: Value engineering, production, planning and control

Concept of value engineering and value analysis, how to reduce the cost of production. Production Planning and Control (PPC).

**WT 4.2 Industrial Waste Treatment & Environmental Management
Summary**

| Credit No. | Credit title | Total hours per credit |
|------------|----------------------------------------------------------------|------------------------|
| 2.01 TC | Waste generation & characteristics of effluent | 15 |
| 2.02 TC | Biological treatment fundamentals | 15 |
| 2.03 TC | Winery and brewery sanitization and waste disposal regulations | 15 |
| 2.04 TN | Waste water disposal systems in industries | 15 |
| 2.05 TN | Water conservation in distilleries | 15 |
| 2.06 TN | Air pollution | 15 |
| | | 75+15=90 |

Note:

1) 3 TC Credits and any 2 Credits from TN.

2) The subject covers total 5 Credits i. e.

Teaching clock hours = 60 clock hours and

Total clock hours per course= 75+15=90 clock hours

2.01 TC: Waste generation & characteristics of effluent. IS norms.

2.02 TC: Biological treatment fundamentals

Waste treatment methods- Types & Selection Criteria, Aeration principles, Aeration & types of system, Composting – microbial aspects & silent features, Economics consideration in composting process, Microbiology & Conversion process in anaerobic fermentation, Kinetics of methane fermentation.

Energy generation and types of anaerobic system, Incineration – Theoretical, considerations, types, incineration systems in practice, Type of secondary treatment system.

2.03 TC: Winery and brewery sanitization and waste disposal regulations

Winery sanitization- The Importance of Cleaning and Sanitation in the Winery, Basic Cleaning, Water Quality, The Solution: Cleaning Compounds, Cleaning Equipment, Sanitizing and Sanitizers, Sterilizing and Sterilizers, Hardware: Tanks, Pumps, Hops, Walls, Floors, Ceilings, Drains, Solid and Liquid Waste Disposal, Government Regulations, Safety, OSHA, EPA, DNR, MSDS, Sanitation Plan.

2.04 TN: Waste water disposal systems in industries

Waste Beer, solid waste materials, wastewater disposal and treatments. Sludge treatment, Disposal and Utilization, Land application of Brewery Effluents, Production of single cell protein from Brewery Effluents.

2.05 TN: Water conservation in distilleries.

Requirement of total water for process and non-process in typical 30 KLPD molasses based distillery. Scope for water recycles of various streams for process. Cost economics of saving of water in distillery with typical case study. Importance of water conservation in distilleries.

2.06TN: Air pollution:

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Air pollution control principles & equipments, Environmental Audit, Disposal of effluent & soil fertility, Environmental laws, Case studies.

Reference Books:

1. T.D. Brock, Biology of Microorganisms.
2. Introduction of Waste water treatment R.S. Ramalho.
3. C.A. Edwards & G.U. Veeresu "Soil Biology & Ecology in India", Published by university of Agricultural Sciences, Hebbal, Bangalore, 1978.
4. R.K. Trivedi, Environmental and Industrial Pollution control. Vol. I

**WT 4.3 Alcohol Technology-III
Summary**

| Credit No. | Credit title | Total hours per credit |
|------------|-----------------------------------------------------------------------------------------------------|------------------------|
| 3.01 TC | Fed batch/Continuous fermentation | 15 |
| 3.02 TC | Alcohol from Non-molasses sources and manufacture of malt alcohol and cost of production of alcohol | 15 |
| 3.03 TC | Multipressure distillation and Molecular sieve dehydration system. | 15 |
| 3.04 TN | Importance of Spectroscopic and chromatographic techniques in alcohol industries | 15 |
| 3.05 TN | Alcohol production from sugar processing intermediates | 15 |
| 3.06 TN | Section wise material balance of typical molasses based distillery | 15 |
| | | 75+15=90 |

Note:

- 1) **3 TC Credits and any 2 Credits from TN.**
- 2) **The subject covers total 5 Credits i. e.**
Teaching clock hours = 60 clock hours and
Total clock hours per course= 75+15=90 clock hours

3.01 TC: Fed batch/Continuous fermentation

Theoretical aspects of continuous fermentation, various types of continuous fermentation systems, continuous Vs Batch Fermentation Systems. Single Fermentation Continuous System (Biostil), Process Details with floe diagrams, Operational aspects, details of plant & machinery. Merits & demerits of the technology, Cascade continuous Fermentation system,, Process details with flow diagram, operational aspects, details of plant & machinery, merits and demerits of technology, Yeast Flocculation Continuous Fermentation System (Encillium - NCL), Process details with flow diagram, operational aspects, details of plant & machinery, Merits & Demerits of technology, Evaluation of Continuous fermentation Technologies. Dry & wet gauging of tanks. Contamination control with special reference to continuous fermentation process.

3.02 TC: Alcohol from Non-molasses sources and manufacture of malt alcohol and cost of production of alcohol

Characterization of various non-molasses sources for alcohol production. Process details of alcohol production from Corn, Sweet Sorghum, Tapioca , Sugarcane Juice and others, Quality aspects of alcohol from non- molasses sources, Production of alcohol from non-molasses sources in the existing molasses based distillery. Manufacture of liquors-Rum, Whisky, Gin, Vodka, brandy, Cachaca, Taquilla etc. & bottling, packing of liquors. Reduction & blending of spirit. Blending and sensory analysis of various spirit and liquors. Details of production of malt alcohol.

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International scenario of alcohol production and potential for import and export.
Typical cost of production of alcohol.

3.03 TC: Multipressure distillation and Molecular sieve dehydration system.

Mechanism, flow diagram and concepts behind Molecular sieve and MPR distillation. The quality aspects of spirit using MPR distillation.

3.04 TN: Importance of Spectroscopic and chromatographic techniques in alcohol industries

Introduction to various spectroscopic and chromatographic techniques useful for alcohol industry. Role of GC-MS, GC, HPLC, HPTLC and other sophisticated instruments in analysis of molasses, fermented wash, RS, ENA, AA, SDS, beer, wine and various beverages.

3.05 TN: Alcohol production from sugar processing intermediates.

Details of sugar processing intermediates, Details of sugarcane juice to ethanol fermentation, Use of B-Heavy molasses for alcohol production, Ethanol blending programme in Brazil and beneficial aspects to industries.

3.06 TN: Section wise material balance of typical molasses based distillery

Material balance of batch and continuous fermentation; Atmospheric and multipressure distillation, Azeotropic and Molecular sieve dehydration system.

Reference Book:

1. The Alcohol Textbook – Jacques, T. P. Lyons & D. R. Kelsall
2. Alcoholometry – Satyanarayana Rao
3. Handbook of Fermentation & Distillation – A.C. Chatterjee
4. Distillation – H.C. Barron
5. Technical Excise Manual
6. Byproducts of sugar industry – Paturao

**WT 4.41 - Second Generation Biofuels
Summary**

| Credit No. | Credit title | Total hours per credit |
|------------|---------------------------------------------------------------------------|------------------------|
| 4.01 TC | Pre-treatments and biochemical routes for hydrolysis of lignocellulosics. | 15 |
| 4.02 TC | Thermochemical route and syngas production | 15 |
| 4.03 TC | Value added products Syngas, Bio-butanol/bio-ethanol production. | 15 |
| 4.04 TN | Microbial genetic/metabolic engineering | 15 |
| 4.05 TN | Algal biofuels | 15 |
| 4.06 TN | Bio-oil by Rapid thermal pyrolysis | 15 |
| | | 75+15=90 |

Note:

- 1) 3 TC Credits and any 2 Credits from TN.
- 2) The subject covers total 5 Credits i. e.
Teaching clock hours = 60 clock hours and
Total clock hours per course= 75+15=90 clock hours

4.01 TC: Pre-treatments and biochemical routes for hydrolysis of lignocellulosics.

Introduction to 1st Generation and 2nd Generation biofuels. Cellulose: What is cellulose? Chemistry of cellulose; Characteristics of cellulose; Details of cellulose, hemicellulose and lignin. Why cellulose is difficult to be broken down? Composition and significance of baggasse, trash and rice straw. Pretreatment of cellulose: 7-8 methods and yield of sugars. How lignin is separated by pretreatment? Uses of lignin. Enzymatic and acid hydrolysis-Advantages and disadvantages. Why enzymatic hydrolysis is more important as compared to acid hydrolysis?

4.02 TC: Thermochemical route and syngas production

Details of cellulose to syngas production.

4.03TC: Value added products Syngas, Bio-butanol/bio-ethanol production.

Introduction to syngas to other biofuels. List of various biofuels obtained from syngas and its economic importance and current scenario. Microorganisms involved in butanol fermentation, Various substrates for production of butanol, Mechanism and biochemistry behind butanol fermentation, Physical, chemical, engineering and downstream processing aspects involved in butanol fermentation, Calorific value as compared to other fuels.

4.03 TN: Microbial genetic/metabolic engineering

Various terminologies used in genetic engineering, Basic aspects of genetic material, various techniques for transfer of genetic material.

4.05 TN: Algal biofuels

Need for algae as alternative feedstock for biofuel generation (Demand, supply and challenges with present generation biofuels). Algae as next generation/potential source of bioethanol and other bio-based chemicals.

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Diversity of feed stocks: Fresh water and Marine water forms. Diversity of genera and Strain isolation screening and selection. Nutrient criteria, physico-chemical parameters for growth of algal forms. (Key Growth Parameters). Culture development/ Types of reactors its advantages and disadvantages. Production, Harvesting and processing of algae. Algal biofuel conversion technologies. Co-products/other energy products from algae.(Green-chemicals bio-plastics) Major advantages, disadvantages and Limitations of algal biofuel production. Current challenges, Future trends(forecast) and perspectives.(Techno-economic Analysis)

4.06 TN: Bio-oil by Rapid thermal pyrolysis

Introduction to bio-oil, Production of bio-oil, Properties of bio-oil-Chemical, physical and environmental aspects of bio-oil, uses of bio-oil, Techniques for fast pyrolysis of biomass.

Reference Books -

1. Second Generation Biofuels And Biomass,Essential Guide for Investors, Scientists and Decision Makers (Ed)Roland A., Jansen,Wiley-VCH Verlag, Weinheim, Germany.
2. Advanced Biofuels and Bioproducts, Lee, James W. (Ed.) 2013, Springer publication
3. *Bioenergy and biofuel from biowastes and biomass.* (Ed), Khanal, Samir Kumar, ed. ASCE Publications, 2010.
4. Microbial Technologies in Advanced Biofuels Production, (Ed), Patrick C. Hallenbeck, Springer Publication
5. Bioethanol Production from Lignocellulosic Materials: Second Generation Biofuels,(ED),[Meena Krishania](#), Lambert Academic Publishing
6. Second Generation Biofuels, Lambert M. Surhone, Miriam T. Timpledon, Susan F. Marseken, VDM Publishing, 2010

**(WT 4.42) Advanced Brewing Technology
Summary**

| Credit No. | Credit title | Total hours per credit |
|-------------------|-----------------------------------------------------|-------------------------------|
| 4.01 TC | Beer types and their special features | 15 |
| 4.02 TC | Fermentation management | 15 |
| 4.03 TC | Bottling/canning the beer | 15 |
| 4.04 TN | Micro/Pub scale brewing | 15 |
| 4.05 TN | Cereal harvesting & storage Malt House practices | 15 |
| 4.06 TN | Energy Management in the brewery & Malting | 15 |
| | | 75+15=90 |

Note:

- 1) 3 TC Credits and any 2 Credits from TN.**
- 2) The subject covers total 5 Credits i. e.**
Teaching clock hours = 60 clock hours and
Total clock hours per course= 75+15=90 clock hours

4.01 TC: Beer types and their special features

Beers Produced by top & bottom Fermentation, Special features of top fermentation, Physiological differences between top fermenting yeast & Bottom fermenting yeast. Assessing yeast Viability, Yeast Viability tests, Yeast Vitality test. Measures of cellular activity, Flurometric Vitality test, Saccharomyces wild yeast, Non Saccharomyces Wild yeasts, Biofilms, Controlling contamination.

4.02 TC: Fermentation management

Wort collection, wort cooling & Clarification, Wort Oxygenation, Control of yeast Pitching rate, Direct Weight of yeast cake, Addition of yeast Slurry Cone- Cone Pitching, use of infrared turbidometry Monitoring, Fermentation Progress, Wort gravity Co2 evolution, PH, rate of O2 assimilation yeast, growth, Ethanol formation Vicinal dike tone Concentration, Effects of process Variables on fermentation Performance, Primary contaminants, Factors influencing abnormal fermentation. Inoculums Preparation & Strain Improvement- Primary Screening, Secondary Screening, Mutation, Natural mutations Artificial induction of mutation, selection of high Producers, Revert mutants. Genetic Engineering of yeast.

4.03 TC: Bottling/canning the beer

Advantages & disadvantages of glass bottles, Glass Bottle Production, Shape Color, Surface coating, Scuffing, Bottle after. coating filling & cleaning of returnable glass bottles, Factors Which influence bottle washing, Design of Bottle washing Machine, Single end, Double end washing Machines, Cleaning & Maintenance Work on Bottle Washing Machine Control of filling process, Closing the Bottles, pasteurizing in bottles, Labeling & foiling the bottles, PET. Bottles, plastic screw cap closures, Can filling, low oxygen closure, closure procedure, Filling of wooden barrels & Casks. Secondary contaminants, beer dispensing.

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4.04 TN: Micro/Pub brewing

Micro Brewers, Hobby brewers, making your own malt. Pub breweries. Plant & Process diagram of pub breweries. The concept of home brewing, The details of home brewing, availability of raw materials kit and basic equipments, Precaution and quality measures for home brewing, Home brew maturation, Fermentation & Maturation cellar, Dispense equipment, Types of Beer. Energy Supplies, Legal Regulations.

4.05 TN: Cereal harvesting & storage, Malt House practices.

Physiology & Biochemical Composition of cereals, Biochemistry of GA3/ aleuronic response in cereals, Structure & Chemistry of cereal grains used for adjunct Production. Cereal adjunct in Brewing & Distilling, Cereals used in Malt Production. Unmated cereals, other brewing extracts & Quality Control Procedure. Physiology of cereal germination. Industrial Licensing.

4.06 TN: Energy Management in the breweries

Energy Management in the brewery & Malting- Energy Requirements in Malting & brewing- Boiler plant types of boiler- Fuels, Steam-Heat of evaporation, Wet steam, Super heated Stream. Hot water, Energy recovery & improvement of Efficiency, Return of Condensate , Refrigeration plant, Refrigerants, Cooling agents, Operating principle of refrigeration, Compressors, Evaporators, condensers, Control valves, Ice water storage. Absorption cooling machines-cooling of Conventional Fermentation & Lager cellars, Stationary cooling, Air circulation cooling, Modern cooling plants, cooling of liquids. Singlestage cooling, Double stage cooling.

Reference Book:

1. American Society of Brewing Chemists, U.S.A.: Methods of analysis of American society of brewing chemists. (8th rev.) U.S.A. American society of brewing chemists, 1996.
2. Arntzen,C.J.,ed.: Encyclopedia of agricultural science, vol. 1: - A - D. N. York, Academic Press, 1994.
3. Birch,G.G.: Alcoholic beverages. London, Elsevier Applied Science Pub.1985.
4. Government of India. Technical Excise Manual. --(663.16GOV)
5. Hardwick,W.A.,ed.: Handbook of brewing. N. York, Marcel Dekker,Inc.,1995.(663.3 HARHAR)
6. Hough,J.S.,Briggs,D.E.,Stevens,R.,Young,T.W.: Malting & brewing science, vol. 2 : hopped wort & water. London, Chapman & Hall, 1982.
7. Pollock, J.R.A., and ed.: Brewing science vol. 1.London, Academic Press, 1979, (663.3POL)
8. Pollock, J.R.A., and ed.: Brewing science, vol. 2. London, Academic Press, 1981. (663.3POL)
9. Prescott, S.C. & Dunn, C.G.: Industrial microbiology. Jodhpur. Agrobios (India), 2002. 81-7754-149-8
10. Priest, F.G.: Brewing microbiology, 2nd ed.. (1996) U.K. Chapman & Hall, 1996. 0412591502--(576PRI)
11. Priest, Fergus G.; & Stewart, Graham G.: Handbook of brewing. (2nd) U.S.A. CRC Press, Taylor & Francis Group, 2006.

(WT 4.43) Advance Enology
Summary

| Credit No. | Credit title | Total hours per credit |
|------------|-------------------------------------------|------------------------|
| 4.01 TC | Principal constituents of grapes and must | 15 |
| 4.02 TC | Control measures during fermentation | 15 |
| 4.03 TC | Principal components of wine | 15 |
| 4.04 TN | Maturation and aging of wine | 15 |
| 4.05 TN | Blending and bottling of wine | 15 |
| 4.06 TN | Wine faults and spoilage | 15 |
| | | 75+15=90 |

Note:

- 1) 3 TC Credits and any 2 Credits from TN.
- 2) The subject covers total 5 Credits i. e.
Teaching clock hours = 60 clock hours and
Total clock hours per course= 75+15=90 clock hours

4.01 TC: Principal constituents of grapes and must.

Sugar, Acid, Mineral Salts, Polyphenols, Tanins, Anthocyanins, Flavor Components, Proteins Colloids, Version & Maturity, Role of Oxygen, Anaerobic Wine Making, Antioxidants, Inert gases, Carbon Dioxide, Nitrogen, Argon, Noble Gases - Helium, Neon, Krypton & Xenon, Dissolved Oxygen, Sparing, Hyper oxidation Micro Oxygenation, Theory & Practice of Carbonation including mix gas technology.

Must Production- Machine harvesting, Destalking, Crushing, Draining juice, Pressing Skin- The basket press, Horizontal screw Press Pneumatic Press, Tank press, Continuous Screw Press, Adjusting Musts- So₂, Clarification, Settling, Centrifuging, Flotation, Acidification, De- Acidification, Enrichment of Grape must. Cryo-extraction, Reverse osmosis. Nutrients & other treatment.

4.02 TC: Control measures during fermentation

Cultured yeast, Control of temp, Monitoring, Stopping the Fermentation & A stuck Fermentation Naturally sweet wines. Malolactic fermentation, Cool fermentation, Skin contact, sur lie Battonage, Prevention of Oxidation, fermentation in barrel Tumultuous fermentation. Maturation in wood.

4.03 TC: Principal components of wine

Alcohol, Acids Volatile Acidity Residual sugar, Glycerol, Aldehydes & Ketones, Clarification & Stabilization – Racking, Protection from Oxidation. Blending, Fining- Fining agent, Blue Fining, Calcium Phytate, Tartarate Stabilization, Cold stabilization Contact process, Electro dialysis.

4.04 TN: Maturation and aging of wine

Objectives of maturation. Containers/cooperages for maturation. Factors affecting maturation of wine. Chemical reactions occurring during wine ageing. Extraction of phenolic compounds from Oak.

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4.05 TN: Blending and bottling of wine

Reasons/necessity for blending of wines. Various precautions/rules taken in to consideration during blending of wine. Bottle cleaning/hygiene measures. Bottling lines and environment. Bottling and corking: Wine bottle closures. Considerations and requirements for glass containers for packaging (Dimensions, volume, homogeneity, Annealing, Thermal shock test etc). Various bottling operations (Quality control, bottling room, dedusting and rinsing of bottles, filling, cork insertion, labeling, capsulation and foiling etc.)

4.06 TN: Wine Faults and spoilage

Beyond Shelf life, Oxidation, Tartarate crystals Foreign bodies, Musty taint, Volatile acidity, Secondary Fermentation Iron casse. Coppe Case. Mousiness, Geranium smell.

Reference Book-

1. The Production of Grapes & Wine in cool Climates. David Jackson & Danny Schuster
2. American Society for Enology & Viticulture 50th Anniversary Annual Meeting June -19-23-2000 Washington State Convention & Trade Linter Seattle, Washington
3. Methods for analysis of musts & wines- IInd Edition C.S.Ough & M. A. Amerine.
4. Understanding Wine Technology-David Bird
5. Practical aspects of Wine Filtration-Bernard Gautier.
6. Better Wines from Concentrates-T. Edwin Belt
7. Wine Marketing & Sales-Success Strategies for a Saturated market-Paul Wagner, Janeen olsen Liz Thach.
8. Wine for Women-Leslie Sbrocco.
9. Hand Book of Enology-Vol-I The Microbiology of Wine & Verification- P. Rebereau Gayon.D. Dulubourdieu, B. Doneche, A.Lonvauel
10. American Society for Enology & Viticulture-Seattle
11. Australian Society of Viticulture & Enology-Andrew Markides Richard Gibson.
12. Introduction to Wine Making Viticulture & Enology Prof. Ralf A.Kunkee.
13. Understanding Wine Course Notes Patric II & Peter Gago
14. Wine Science- Ron S. Jackson
15. Hand Book of Enology-Vol.2-The Chemistry of Wine Stabilization & treatments- P. Rabereau, Gayon D.Dalabourdieu, A. Maujean, Y. Glories.
16. Concepts of Wine Chemistry-The Wine appreciation Guide-Vair Margalit, James Cram.
17. Wine Making From Grape growing to Market Place Richard P. Vine, Elien Harkness. Salley J. Linton
18. Monitoring the Wine Making Process From grapes to wine techniques & Concept- Patric I Land. Nick Bruer, Andrew EWART. Andrew Markides John Sitters.
19. Wine Appreciation-Richard P. Vine

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(WT. 4.5) Short term research project (Individual/groups) OR In plant training in industry.

The Opportunity to analyze a particular industry based problem or topic in depth. Conduct a relevant lab or library- based study. To provide a chance to improve fundamental research & analysis, skills & advance understanding of then processes involved in Wine technology, Brewing technology or Alcohol technology. Student has to undertake an extended investigation in an advanced topic of relevance to their degree discipline or to their Sponsoring industrial partner. The research project builds on the taught modules of the course. Students should analyses their results & present the same in the form of a dissertation that includes a review of previous research & set their work in context with critically argued discussion. Students should contribute via seminars or posters or publication to the research activity of the host /work institution.